Gouania podocephala Killip.

Gouania ulmifolia Tr. & Planch. Ann. Sci. Nat. V. Bot. **16**: 382. 1872. Not Hook. & Arn., 1833.

Voyria macrantha Killip, sp. nov.

Caulis crassus, prope apicem ramis 1–2 brevibus; squamae ovatae, apice rotundatae, per partem tertiam connatae; calycis tubus cylindrico-campanulatus, lobis 5, late ovatis, rotundatis; corolla rubro-purpurea, extus ad basin glabra, ad apicem puberulenta, intus pulverulenta, limbo rotato, 4 to 5 cm lato, ad faucem lobato, lobis 5, obovatis vel rhombeo-obovatis, obtusis; antherae ovatae; capsula ovoidea.

Stem stout, 6 to 7 cm high, about 2 mm thick, erect, once-branched near apex, glabrous; scales opposite, 6 to 12 mm apart, ovate, 3 to 6 mm long, rounded, connate in lower third, the sinus acute; peduncles up to 13 mm long, stout, gradually widening to calyx; calyx tube cylindric-campanulate, about 1.5 cm long, 5 to 6 mm wide at throat, the lobes 5, broadly ovate, 1.5 to 2 mm long, 3 to 4 mm wide, rounded, minutely ciliolate, glabrous otherwise; corolla bright red-purple, the tube cylindric, 3.5 to 4.5 cm long, glabrous at base without, puberulent on upper half without, pulverulent within; the limb rotate, 4 to 5 cm wide, lobed to throat, the lobes 5, obovate or rhombic-obovate, 2 to 2.4 cm long, 7 to 11 mm wide, obtuse; filaments inserted about 5 mm below throat of tube, 0.5 to 1 mm long; anthers ovate, 1 to 1.5 mm long; style slender, about 3.7 cm long; stigma capitate, papillose on upper surface, smooth beneath; ovary sessile; capsule ovoid, 1 cm long, 6 mm in diameter.

Type in the herbarium of the Jardín Botánico, Madrid, collected in Colombia, between 1760 and 1808, by José Celestino Mutis (no. 3054). Represented also by *Mutis* 2566. Known also from the following Colombian collections:

Dept. Sur de Santander: " Camp Carare II," *Haught* 1621 (U.S.N.H.). "Camp Aguila," Carare Valley, *Haught* 1871 (U.S.N.H.).

The flowers of *V. macrantha* are much larger than in other species of *Voyria* or in the closely related genus *Leiphaimos*. Apparently the species comes nearest *V. caerulea* Aubl. but in addition to having larger flowers than *V. caerulea*, the scales and the calyx lobes are rounded, not acute.

ZOOLOGY.—*Radular movement in gastropods.*[1]

GORDON GUNTER, Bureau of Fisheries. (Communicated by PAUL S. GALTSOFF.)

Cuvier[2] in 1817 described the radula in gastropods as a passive instrument moved secondarily by its supporting cartilages. Huxley[3] (1853) disagreed with him and maintained that the radula executes movements independent of its cartilages and moves over them "chain-saw-like." He believed that this type of movement prevailed "throughout the Cephalopoda and Gasteropoda." Most of his argument was

[1] Printed by permission of the Commissioner of Fisheries. Received February 20, 1936.
[2] Memoire pour servir a l'histoire et a l'anatomie des mollusques. Paris. 1817.
[3] Phil. Trans. Roy. Soc. London **143**: 29–65. 1853.

based on anatomical structure, but he stated that the apparatus could "be seen working in *Firoloides* and *Atlanta.*"

Most writers in describing the odontophoral apparatus in gastropods have not mentioned the issue, but there have been adherents of both theories. Lacaze-Duthiers[4] (1856), Geddes[5] (1879), Amaudrut[6] (1898) and Simroth[7] (1901) rejected Huxley's hypothesis for that of Cuvier, either by direct statement or by implication in their descriptions. Geddes studied under Huxley and took up the subject at the latter's instigation. He rejected the chainsaw idea and concurred with Cuvier. His objection to Huxley's theory was based principally on the close attachment of the radula to the radular sac by the radular membrane and his belief that the radula could not slide over the acute angle formed by the apex of the cartilages.

Wegman[8] (1884) in describing *Haliotis* stated that the radular membrane slides over the cartilages, which implies that the radula does also. Herrick[9] (1906) in describing the anatomy of the odontophore of *Busycon canaliculatus* sided with Huxley, and gave a very clear exposition of his conception of its mode of action. Dakin[10] (1912) working on *Buccinum* also followed Huxley. He stated that the radula could be made to slide over the cartilages in narcotized animals by pressing the proboscis between the thumb and forefinger. Both he and Herrick stated as further evidence for their belief, that radular movement could be felt when animals were induced to rasp the finger tip. The writer has repeated this experiment with *Melongena corona* and *Thais floridana*, but has found it impossible to tell by such means whether the radula slides or is passively borne by the cartilages.

Because of the internal position of the radula in the radular sac within the proboscis, its small size, and the fact that when in use the whole proboscis is often covered by the foot and its open end is placed on the food, observation of the living animal in the natural state seems to be almost impossible. These obstacles are probably the reasons why such observations, which would have settled the question, have been few and relatively incomplete. Some workers have stated that they have observed living animals, but most of their conclusions appear to be drawn from the anatomy, and the writer has not found

[4] Ann. Sci. Nat. **6**: 225–281. 1856.
[5] Trans. Zool. Soc. London **10**: 485–491. 1879.
[6] Ann. Sci. Nat. **7**: 1–291. 1898.
[7] Bronn's Klassen und Ordnungen des Thier-Reichs. Band 3. Leipzig. 1901.
[8] Arch. Zool. Exper. et Gen. **2**: 289–378. 1884.
[9] Amer. Nat. **40**: 707–737. 1906.
[10] Liverpool Marine Biology Committee Memoirs **20**: 1–115. 1912.

a complete description of radular movement based on direct observations of the odontophoral mechanism at work in the living animal.

Fasciolaria gigantea of the Florida coast is an ideal animal for study and observations were made on it at the Indian Pass Laboratory of the United States Bureau of Fisheries. It is one of the largest gastropods in the world and has a radula 2 mm. wide. When stimulated by a bit of oyster meat it gives the usual food reaction of carnivorous gastropods which culminates in the extrusion of the proboscis. This has been described in detail by Copeland[11] for *Nassa obsoleta* and *Busycon canaliculatum.* If the food is withdrawn the odontophore may be seen through the proboscis opening, with the naked eye, to continue working in the following manner. The cartilages bearing the radula move forward and upward with a licking motion. At the same time the radula moves upward and over the cartilages like a chainsaw or belt over a pulley, with a motion so rapid that it gives the illusion of rapid rotation. When the odontophore reaches the end of the forward movement it begins to move downward and backward. At the same moment the radula reverses its direction, almost too speedily for detection, and slides downward and under the cartilages. As the forward movement of the cartilages is started again the radula repeats the movement first described. The whole process proceeds at an even rate so that the radula has the appearance of a rapidly spinning wheel being carried back and forth on a frame. As Herrick (op. cit. p. 721) has pointed out the teeth are folded together as they pass back and forth under the cartilages and rasping can only be done during the upward stroke. The mouth is situated so that food can be drawn into it only by this movement and not by the downward one. In *Thais* the food may be seen to progress down the proboscis in peristaltic waves, which are apparently timed and initiated by the piston-like strokes of the odontophore.

The objections of Geddes and others to the theory that the radula has motion independent of that of the cartilages, were based on anatomical studies and cannot hold in the face of observations to the contrary on living animals. He seemed to disregard the significant fact that the radula is a long, ribbon-like, jointed apparatus, borne on a very flexible membrane; the whole being eminently fitted for the band-over-pulley type of function. The plates bearing the teeth are loosely joined together so that the whole radula can bend back upon itself. This jointed structure allows the radula to move over the apex

[11] Jl. Exp. Zool. 25: 177–227. 1918.

of the cartilages as described for *Fasciolaria*. The radula is not too closely attached to the radular sac, as Geddes stated, or too firmly attached to the cartilages for independent movement, as shown by the fact that in *Thais floridana* and *Thais sp.* the radula of an amputated proboscis can be made to move over the cartilaginous support while the latter is perfectly stationary. These animals are very similar in structure to *Buccinum*, one species upon which Geddes worked and arrived at the opposite conclusion.

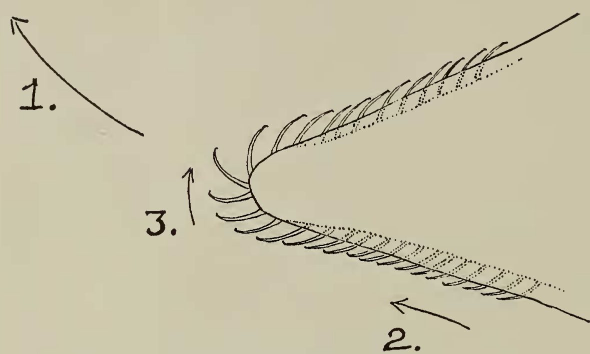

Fig. 1.—Diagrammatic side view of radula.

These studies apparently prove the hypothesis of Huxley and his adherents concerning the band-over-pulley movement of the radula. Yet Huxley (op. cit. p. 31) stated that "the buccal cartilages take no part in the movement of the tongue-plate." As shown in the above observations this is incorrect, at least for the forms described here. Von Siebold (quoted by Huxley, loc. cit.) had previously recognized that the cartilages play a part for he stated that by protrusion and retraction this organ is used by the Cephalophora as an ingestive apparatus. Oswald[12] (1893) seems to have first realized that both movements were concerned, although he said the band-over-pulley motion was very limited.

The illusion that a radula in operation is a small wheel is very significant, for it can be shown by reference to the description above and the accompanying diagram that the radula is functionally a small, rapidly rotating wheel or drum covered on the outside with small spikes.

As the cartilaginous frame moves forward and upward its trajectory is that of an arc as shown by arrow number 1 of the diagram. At

[12] Jen. Zeitschr. f. Naturw. 28: 119–162. 1893.

the same time the radula is pulled up and over the apex of the cartilages by the radular muscles in the direction shown by arrow 2. This imposes a second speed on the first. The teeth sliding over the apex are held at right angles to the ribbon and pulled in the arc shown by arrow 3. From the simple law that the speed of a turning wheel is greatest at its circumference, it is seen that the barbs of the teeth at this point are moving at a greater speed than the ribbon itself or the teeth at any other point of the radula. This superimposes a third speed upon the other two, and it is easily seen how the illusion of a rotating wheel is created. This simple mechanical adaption moves the functional part of the radula at a rapid, but undetermined speed, and probably accounts to a large extent for the ability of many gastropods, such as *Thais, Murex, Eupleura, Urosalpinx* and *Buccinum* to bore through the hard shell of other mollusks. It is also possible that the radula is assisted by an acid secretion which softens the shell.

The distinctive structure of the odontophoral apparatus and its similarity in prosobranchiate gastropods leads the writer to believe that this mode of radular movement is typical for most prosobranchs and probably many other gastropods. Observations on *Thais floridana, Thais sp.*, and *Melongena corona* substantiate this hypothesis.

The writer is indebted to Dr. A. S. Pearse for the specimens of *Fasciolaria.*

ZOOLOGY.—*Copepods from the far north collected by Capt. R. A. Bartlett.*[1] CHARLES B. WILSON, Westfield, Massachusetts. (Communicated by MARY J. RATHBUN.)

For several years Capt. R. A. Bartlett has been gathering plankton from the coasts of Labrador, Canada and Greenland, the last cruise taking place during the summer of 1935. The samples thus accumulated have been submitted for examination by the National Museum and the copepods found in them are here listed. The localities from which the plankton was obtained may be conveniently divided into four groups according to geographical location. The first group extended along the entire coast of Labrador from 52 to 60 degrees North Latitude, and included several fishing and whaling grounds. The second group began at the mouth of Hudson Strait, just north of Labrador and extended northwest up the strait into the northern end of Hudson Bay, and thence into Fox Channel, a northern arm of the bay reaching into the Arctic Zone south of Baffin Island. In this

[1] Received March 18, 1936.